TANTALUM.

THE application of electricity to chemical problems has again borne fruit in the isolation and preparation of tantalum. Dr. Werner von Bolton, of the firm of Siemens and Halske, published the results of his very interesting research upon the preparation of tantalum in the *Zeitschrift für Elektrochemie* (January 20). Although the existence of tantalum was pointed out by Hatchett in 1801, it does not appear up to the present to have been prepared in the pure condition. Moissan, indeed, in 1902 prepared the metal by reducing tantalic oxide (Ta_2O_5) in the electric furnace. But the metal was extremely hard and brittle, a property which Dr. Bolton now shows only belongs to the impure product; Moissan's metal probably contained some carbide. Dr. Bolton has succeeded in obtaining the metal by an electrical and by a chemical method.

The Electrolytic Method.

As is well known, Nernst found that when a thin rod of magnesia (MgO) is heated to whiteness it becomes able to conduct the electric current, the magnesia being split up into its components, magnesium and oxygen; the magnesium, however, immediately re-combines with oxygen, the process of electrolysis therefore becoming continuous. Other metallic oxides, such as zirconium, ytterbium, thorium, calcium, and aluminium, &c., likewise behave in a similar manner. If, now, a rod of magnesium is strongly heated in vacuum and the electric current passed through it, the oxygen given off is so dilute that re-combination does not take place, and the rod becomes powdered. Dr. Bolton, working along somewhat similar lines, found that the coloured or lower oxides of vanadium, niobium (columbium), and tantalum will conduct the electric current without the necessity of being heated to very high temperatures. Strange to say, the colourless or higher oxides have not this property.

In order to prepare tantalum in this manner a filament of the brown tantalum tetroxide (Ta_2O_4) was prepared and fixed into an evacuated globe, which was connected with a vacuum pump, so that if oxygen was given off, on heating, it could be pumped out. On passing a current through this filament, at first the two ends of the filament became white hot, and then gradually the incandescence travelled along the filament until the whole of it became incandescent. A large quantity of oxygen was given out, and the filament, which at the commencement was brown, became metallic grey. The tantalum so obtained showed on analysis a purity of 99 per cent.

The Chemical Method.

Details as to how the chemical method is carried out are not given. Dr. Bolton simply says that the metal can be obtained by fusing a mixture of potassium tantalum fluoride with potassium by means of the electric arc furnace in a vacuum. This method is a modification of that used by Berzelius in 1824.

Properties of the Metal.

One of the most remarkable properties of the metal is its extreme ductility combined with extraordinary hardness. The red-hot metal can readily be rolled into sheets and foil, and easily drawn into wire. When the sheet is again heated and hammered it becomes so extremely hard that it was found impossible, by means of a diamond drill, to bore a hole through a sheet 1 mm. thick. The drill, rotating 5000 times to the minute, was worked day and night for three days, and at the end of the time had only made a depression 0·25 mm. deep, while the diamond of the drill was very much worn. This property may very probably lead to its being used for drills in place of the diamond.

The metal melts between 2250° and 2300°. The atomic heat agrees with the law of Dulong and Petit, being 6·64. The specific gravity is 14·08. When two electrodes of tantalum are placed in a bath of dilute sulphuric acid, the tantalum becomes passive, and even with an E.M.F. of 220 volts at the terminals no current passes. When placed opposite an electrode of platinum only one phase of an alternating current passes; it may thus be used for rectifying an alternating current in the same manner that aluminium can.

In the form of wire, sheet or ingots, the metal is unacted upon by sulphuric, hydrochloric, or nitric acid, and even by aqua regia. Hydrofluoric acid reacts very slowly, unless the metal is in contact with platinum, for example, in a platinum dish, when it dissolves readily with evolution of hydrogen. Fused alkalis have no action upon it.

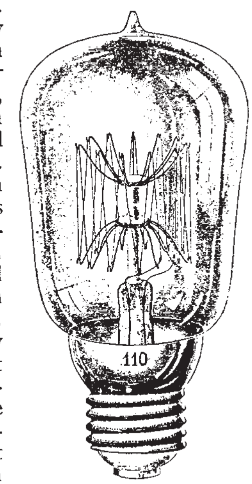

FIG. 1.—View of Tantalum Lamp. Half-size linear.

When made the kathode in an acid electrolyte it absorbs hydrogen, which is only partially given up, even when the metal is fused. The metal may be heated to red heat in the air without taking fire. At 400° it turns slightly yellow, at a low red heat it turns blue, and finally becomes coated with a white protective coating of the pentoxide. It absorbs nitrogen at a white heat, and unites with sulphur when melted with it under fused potassium chloride. Tantalum apparently forms no amalgam with mercury, although it produces alloys with most other metals. When united with 1 per cent. of carbon it becomes hard and brittle, and can no longer be drawn into wire.

As already stated, the original idea in working with tantalum was to find a new material to be used for incandescent electric lamps. The first experiments were tried with the oxides of vanadium and niobium (columbium); the coloured or lower oxides of these metals were found to conduct the current and to give up their oxygen when thus heated in vacuum. Vanadium so obtained was found to melt at 1680° and niobium at 1950°; but owing to these comparatively low melting points they could not satisfactorily be employed for electric lighting purposes. Tantalum, however, which melts between 2250° and 2300°, has been successfully employed for this purpose by Messrs. Siemens and Halske.

Filaments of the metallic tantalum are fused into a globe, which is then evacuated in the usual manner. The first lamp was made with the usual bow-shaped filament, and required 0·58 ampere with a pressure of 9 volts, giving 3 candle-power. It was then found that in order to produce a 22 candle-power lamp suitable to being placed on a 110-volt circuit more than 20 inches length of filament was required. The difficulty presented was to get this great length of filament conveniently into the ordinary sized globe. The illustration (taken from the *Electrical Magazine* for March) shows how the difficulty was got over. The central support is a rod of glass, having a number of wires radiating from it to act as supports. This

lamp gives 22 candle-power with an energy consumption of 1·7 watt per candle-power, or about half that required by the ordinary incandescent lamp. The weight of a single filament is 0·022 gram, so that 1 kilogram of metal would be sufficient for 45,000 such lamps.

Whether it will be possible to obtain sufficient mineral to produce tantalum on a really large scale remains to be seen, because if it is possible there should be hardly an end to the usefulness of this metal, which possesses the properties ductility and hardness in such an extraordinary degree, leaving entirely out of question its employment in electric lamps. F. MOLLWO PERKIN.

PRIMITIVE WATER-SUPPLY.[1]

THE mighty earthworks that still crown so many of our hills fill the archæologist alike with wonder and despair—wonder that prehistoric man, with the most primitive tools, was equal to the task of raising them, and despair that so little can ever be known about them, despite the most laborious and costly excavation. Plenty of books, however, of the kind now under notice would do much to solve the mystery and increase our admiration for Neolithic man, for it is to the period before bronze was known in Britain that the authors assign the stupendous works of Cissbury and Chanctonbury on the South Downs.

This is an open-air book that gives life to the dry bones of archæology, and reads like the record of a well-spent holiday. A keen eye for country is one of the qualifications possessed by one or both the authors, and evidence of ramparts long since levelled is wrung from the very daisies as they grow. The construction of dew-ponds by the early inhabitants of Britain has often been glibly asserted, but few, if any, have furnished such clear and circumstantial evidence as the authors of this short treatise. The water-supply for the occupants of our huge prehistoric "camps" has always been somewhat of a mystery, and it has been suggested that they were only temporary refuges, when the country was "up," so that a permanent supply was not regarded as a necessity. But the watering of men and animals on the scale indicated by the areas enclosed would be a formidable task even for a day, and another explanation must be sought. The late General Pitt-Rivers, for example, held that the water-level of the combes was higher then than now, and streams would have been plentiful on the slopes; but, feeling the inadequacy of this view, he also had recourse to the dew-pond theory. To those familiar with the process, this might seem an obvious expedient, but the interesting account given of the formation of such reservoirs might make us chary of crediting prehistoric man with such scientific methods.

An exposed position innocent of springs was selected, and straw or some other non-conductor of heat spread over the hollowed surface. This was next covered with a thick layer of well puddled clay, which was closely strewn with stones. The pond would gradually fill, and provide a constant supply of pure water, due to condensation during the night of the warm, moist air from the ground on the surface of the cold clay. Evaporation during the day is less rapid than this condensation, and the only danger is that the straw should be sodden by leakage. It is for this reason that springs or drainage from higher ground are avoided, as running water would cut into the clay crust.

Some ponds of this kind, no doubt of very early and perhaps of Neolithic date, may still be seen in working order: others are of modern construction; but to and from the ancient dew-ponds (or their sites) can sometimes be traced the hillside tracks along which the herds were driven, one leading from the camp, or cattle-enclosure hard by, to the watering-place, another leading back, to avoid confusion on the road. These and other details as to guard-houses and posts of observation are brought to our notice in the description of selected strongholds in Sussex and Dorset; and verification, if, indeed, such is demanded, must be sought on the spot by any who have doubts or rival theories.

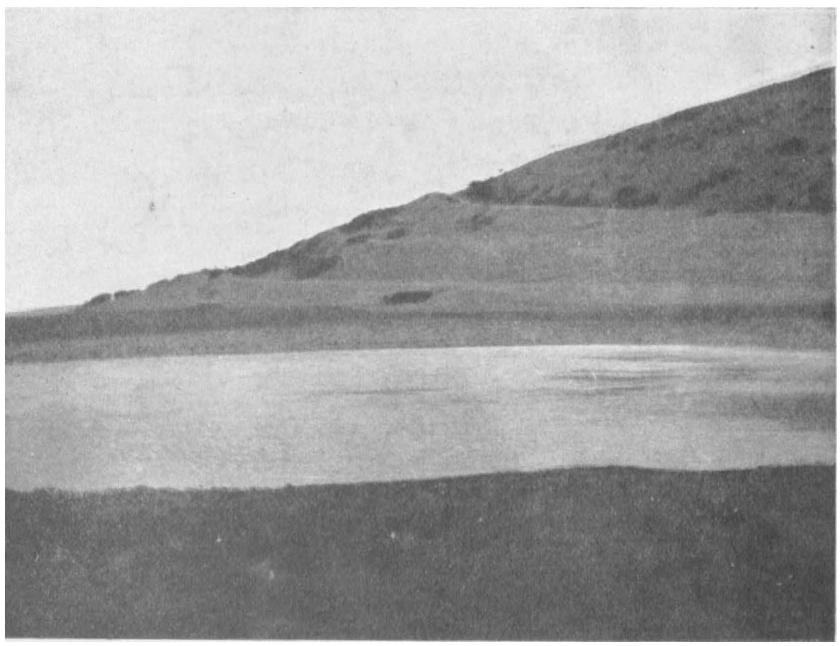

FIG. 1.—Cattle-ways leading down to Dew-pond at the North of Cissbury Ring. From Hubbards "Neolithic Dew-ponds and Cattle-ways."

The banks, that enclosed pasture-areas sometimes of vast extent, were no doubt stockaded against man and beast, and may be compared with the base-court defences of the Norman burh; but the excavator of Wansdyke had an alternative theory that such banks were sometimes erected for driving game. Incidentally, the authors discountenance the view that the "camps," not to mention the outworks, were ever efficiently manned. Their extent would necessitate for this duty a vast number of fighting men within call.

[1] "Neolithic Dew-ponds and Cattle-ways." By A. J. Hubbard and G. Hubbard. Pp. x+69; illustrated. (London: Longmans, Green and Co., 1905.) Price 3s. 6d. net.